

# Cerebro-spinal Fever in the Royal Navy (August 1st, 1916—July 31st, 1917)

BY

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# CASES OF CEREBROSPINAL FEVER IN THE ROYAL NAVY, AUGUST 1, 1916—JULY 31, 1917.

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IN addition to the cases of cerebrospinal fever in the Royal Navy during the third year of the war the total number of cases occurring since the onset of hostilities have been analysed as far as is necessary for purposes of comparison.

The present report contains :—

- (1) Remarks on the incidence of the cases.
- (2) Remarks on some clinical aspects.
- (3) A summary of the results of treatment.
- (4) A brief history of the outbreaks at various centres.

## (1) INCIDENCE OF THE CASES.

During the year August 1, 1916, to July 31, 1917, there were 143 bacteriologically proved cases of cerebrospinal fever as compared with 104 during the second and 170 cases during the first year of the war, the percentages for the first, second, and third years being 41, 25, and 34 of the total 417 cases. The rise during the third year of the war cannot be entirely explained by the increased personnel of the Navy, as there was a distinct fall in the number of cases during the second year as compared with the first year of the war, whereas the personnel presumably continued to increase throughout the war. The absolute rise of the Naval cases during the third year of the war corresponds with a rise in the number of cases in the civil and military populations,<sup>1</sup> and also with an increased percentage of carriers in the Navy.

Bacteriological examination of the throats of new entries from December, 1916, to the end of July, 1917, made at Haslar (Hon. Staff Surgeon P. Fildes, R.N.V.R.), Plymouth (Fleet Surgeon R. S. Bond), Chatham (Staff Surgeon J. H. Burdett), and of non-contacts (new entries and drafts) at Greenwich (Deputy Surgeon-General P. W. Bassett-Smith, C.B.) showed that out of 46,107 officers and ratings there were 1,509 carriers, or 3·3 per cent., as compared with 2·7 per cent. obtained in a similar but smaller collection of cases during the first half of 1916. During the third year of the war the percentage of carriers at different centres varied from 0·1 at Plymouth to 5 at Greenwich, and also varied at different periods (*vide* pp. 17, 22).

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<sup>1</sup> Information kindly given by Dr. T. H. C. Stevenson, of the General Register Office, and Surgeon-Colonel R. J. Reece, C.B., H.A.C.



Out of the 143 cases the large depots at Portsmouth (46), Plymouth (36), the Crystal Palace (18), and Chatham (10), provided 110 or 77 per cent., and sea-going ships 20 or 14 per cent. The Royal Marine Light Infantry Depot at Deal did not have any case. Out of the 417 cases of cerebrospinal fever in the Navy during the first three years of the war, 310, or 75 per cent., arose in the large depots at Portsmouth (110), Plymouth (94), the Crystal Palace (59), and Chatham (49), while 42 cases, or 10 per cent. were reported from sea-going ships. No case of proved meningococcic meningitis has occurred at Osborne or Dartmouth during the war.

The monthly incidence with the results is shown below. The largest number of cases and deaths occurred in January. In the two previous years of the war the largest number of cases and of deaths occurred in February.

	Cases			Deaths			Recoveries		
1916 August	...	3	...	1	or 33·3	per cent.	...	2	or 66·7
September	...	5	...	1	„ 20	„	...	4	„ 80
October	...	3	...	1	„ 33·3	„	...	2	„ 66·7
November	...	6	...	3	„ 50	„	...	3	„ 50
December	...	14	...	7	„ 50	„	...	7	„ 50
1917 January	...	30	...	13	„ 43·3	„	...	17	„ 56·7
February	...	22	...	7	„ 31·8	„	...	15	„ 68·2
March	...	27	...	7	„ 25·9	„	...	20	„ 74·1
April	...	13	...	5	„ 38·5	„	...	8	„ 61·5
May	...	11	...	4	„ 36·4	„	...	7	„ 63·6
June	...	5	...	1	„ 20	„	...	4	„ 80
July	...	4	...	2	„ 50	„	...	2	„ 50
		143		52				91	

Out of the 143 cases 92, or 64·3 per cent., occurred during the first four months of the year, and out of the total 417 cases during the first three years of the war 299, or 71·7, arose during the first four months of the year.

MONTHLY INCIDENCE AND MORTALITY DURING THE THREE YEARS OF THE WAR.

		Cases				Mortality			
		1914-15	1915-16	1916-17	Total	1914-15	1915-16	1916-17	Total
August	...	0	4	3	7	0	2	1	3
September	...	0	4	5	9	0	3	1	4
October	...	0	3	3	6	0	1	1	2
November	...	1	6	6	13	0	5	3	8
December	...	2	8	14	24	1	4	7	12
January	...	27	8	30	65	16	3	13	32
February	...	60	26	22	108	35	7	7	49
March	...	35	20	27	82	15	6	7	28
April	...	24	7	13	44	8	2	5	15
May	...	12	7	11	30	8	0	4	12
June	...	6	3	5	14	4	2	1	7
July	...	3	8	4	15	3	2	2	7
		170	104	143	417	90	37	52	179

Out of the 143 cases 18, or 12·6 per cent., proved fatal within forty-eight hours of the onset; of these fulminating cases 5 arose in January, 3 in November, 2 in December and in June, and 1 each in the other months except August and May. Twelve or two-thirds of the fulminating cases occurred before February, thus conforming to the rule that such cases are commoner at the commencement of than later in an epidemic.

*Age Incidence.*—Among the 143 cases 92, or 64·4 per cent., were under 20 years of age (110, or 76·9 per cent., being under 25 years of age), and the number of cases progressively diminished in the succeeding decades. In the two previous years of the war the percentage mortality of the cases under 20 years of age was lower than in the succeeding decades, whereas in the third year of the war it was considerably higher than in the two succeeding decades. The average age of the 143 cases was 21·5 years, of the 52 fatal cases 21·7 years, and of the 91 recoveries 21·3 years. The extremes of age were 15 and 55 years.

Age periods		Number of cases and percentage of the total 143 cases		Deaths and percentage in the age periods	
15-19	...	92	or 64·3 per cent.	...	36 or 38·1 per cent.
20-29	...	33	„ 23 „	...	10 „ 30 „
30-39	...	11	„ 7·7 „	...	3 „ 27·2 „
40-49	...	5	„ 3·5 „	...	2 „ 40 „
50	...	2	„ 1·4 „	...	1 „ 50 „
		143		52	

The mortality in the same age periods for the 417 cases during the first three years of the war is given for comparison :—

Age periods		Number of cases and percentage of the total 417 cases		Deaths and percentages in the age periods	
15-19	...	265*	or 63·5 per cent.	...	101 or 38·1 per cent.
20-29	...	100	„ 24 „	...	49 „ 49 „
30-39	...	30	„ 7·2 „	...	15 „ 50 „
40-49	...	17	„ 4·1 „	...	11 „ 64·7 „
50-59	...	5	„ 1·2 „	...	3 „ 60 „

\* 67 of these with 26 deaths, or 39 per cent., being in the boy-training establishments “Impregnable,” “Powerful” and Shotley barracks.

*Mortality.*—Out of the 143 cases, 52, or 36·2 per cent., proved fatal as compared with 35·6 per cent. in the second and 52·9 per cent. in the first year of the war. Among 417 cases of cerebrospinal fever in the Navy during the first three years of the war there have been 179 deaths or 42·9 per cent., of which 124, or 69·3 per cent., occurred in the first four months of the years.

*Day of death:* Five cases were fatal on the first day, 4 on the second, 7 on the third, 8 on the fourth, 2 on the fifth, 2 on the sixth day; 5 in the second week, 10 in the third week, 3 in the fourth week, 2 in the fifth week, 2 in the sixth week, and single cases on the fifty-seventh and sixty-



seventh days. More than half the cases therefore were fatal during the first six days of the disease, and 6 so rapidly that no treatment of any kind was employed; 2 of them were found dead and had not been under medical observation.

*Ranks and Ratings.*—There were 6 officers: a Lieutenant-Colonel R.M.L.I. (fatal), a Commander (fatal), a Lieutenant (recovery), and 3 Midshipmen R.N.R. (recoveries). The 137 ratings were Seamen 62 (21 deaths), Boys (seamen class) 21 (11 deaths), Stokers, 20 (8 deaths). Royal Naval Air Service Mechanics 10 (4 deaths), Marines 6 (1 death), Ship's Stewards 5 (1 death), Officers' Stewards 3 (1 death), Sick Berth Staff 3 (0 death), Trimmers 2 (1 death), Wiremen 2 (0 death), Boy Servant 1 (fatal), Naval Apprentice 1 (fatal), and Cook's Mate 1 (recovery).

## (2) REMARKS ON SOME CLINICAL ASPECTS.

*Onset.*—Usually the initial symptoms are malaise, fever, headache, vomiting, and progressive increase of nervous symptoms, so that within twenty-four hours the condition is highly suggestive. In some cases the onset is more gradual with somewhat indefinite symptoms lasting several days. In others it is startlingly acute; thus in 2 cases it was maniacal, in 2 convulsions were the first sign, in 5 (3 fatal) the first indication of illness was fainting, and in 4 instances (2 fatal) the patient was found unconscious. Death in this apoplectiform mode of onset seems to be the probable explanation of the following cases:—

A man, aged 40, who went to bed at 7.45 p.m., feeling ill, but saying he would be all right next morning, was found dead in his hammock at 6 a.m. A boy at Shotley, aged 15, complained at 9 p.m. of slight sore throat, for which he did not seek medical treatment; at 3.30 a.m. next day he was found dead. In these two cases the diagnosis was made from examination of the cerebrospinal fluid after death.

Among 247 cases of cerebrospinal fever in the second and third years of the war, 12, or 5 per cent., had this form of onset and 6 of them proved fatal. The initial shock may be so considerable that for a time the temperature may be normal, or below normal, though it rises in a few hours; this was noted in 6 cases (3 fatal); one of these patients was unconscious when first seen, and in another who was operated upon for a diagnosed gastric ulcer perforation, and found to have a normal abdomen, lumbar puncture was at once performed at the suggestion of the anæsthetist, Temporary Fleet Surgeon C. W. Morris, and turbid fluid containing meningococci obtained. Transfer to hospital may be followed by alarming collapse; one patient died in the ambulance and another a few hours after admission. Vomiting and diarrhoea are common at the onset and in rare instances, (4, 3 fatal) were accompanied by so much abdominal pain as to imitate acute abdominal disease.

When the onset is gradual and preceded by catarrh it may be difficult to decide whether the meningococcic invasion is superimposed on an ordinary influenza or catarrh or whether the "catarrh" is the commence-



ment of the disease. In 3 cases signs of meningitis appeared six days after the onset of rubella, in one instance twelve days after admission to hospital for chicken-pox, in two patients while in hospital with bronchitis and suspected pulmonary tuberculosis respectively, and in another case the day after discharge for bronchitis. The liability of new entries to be attacked, which is usually explained as due to diminution of their resistance by the trials incident to the change from civilian life, was shown by the occurrence of the disease within three weeks of joining the Service in 31, or 21·7 per cent., of the 143 cases; one of these, a man aged 40, who had left the Service seventeen years before he was called up again, was found dead in his hammock. The average age of the other 30 cases was 19·3 years. Many of these new entries had been vaccinated shortly after joining. The mortality of the 31 cases, 10 (32 per cent.), is below that (36·2 per cent.) of the 143 cases. These various factors would favour systemic invasion by meningococci.

*Rashes* due to cerebrospinal fever were recorded in 86 or 60 per cent. out of the 143 cases. The characteristic rash is hæmorrhagic. It may come out rapidly, and progressively increase in extent and size, especially in the fulminating cases; so that though there is no rash when first seen, a few hours later it is well out. In other cases there is first an erythema, macular or blotchy, or a rose spot eruption which subsequently becomes petechial or hæmorrhagic. The rash may not present more than one stage; it may be purpuric from the start, or may not advance beyond the erythematous stage. The cases in which the rash has become hæmorrhagic are entered as such, and only those which remained erythematous, macular, or blotchy, are so classified. The erythema has been described as a premeningitic rash,<sup>1</sup> and as transient; this is probably why it is so seldom recorded. Out of the 86 cases, 70 were described as hæmorrhagic, 10 as mottled, blotchy, or erythematous; and 5 as rose spots. In one instance ulceration occurred in the larger purpuric patches, a very rarely recorded complication; cases have been reported by Bovaird,<sup>2</sup> Robb,<sup>3</sup> and Elliott and Kaye<sup>4</sup> (complicated by trench feet); all the four patients recovered.

Out of the 86 cases 36, or 43 per cent., proved fatal, as compared with the mortality of 36·2 per cent. for all the 143 cases. As is well known, the fulminant and most acute cases are especially prone to have a hæmorrhagic rash; out of the 28 cases fatal during the first week of the disease, 22 (or 78·6 per cent.) had a rash, all the 5 cases fatal during the first twenty-four hours of the disease showing it; while out of the 24 cases fatal later than the end of the first week, 14, or 58·3 per cent., had a rash. Among 410 cases of cerebrospinal fever in the Navy during the war rashes were

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<sup>1</sup> Symonds. *Lancet*, 1917, vol. ii, p. 86.

<sup>2</sup> Bovaird, D. *Arch. Int. Med.*, Chicago, 1909, vol. iii, p. 267.

<sup>3</sup> Robb. *Proc. Roy. Soc. Med.* (Therap. and Pharm. Sect.), Lond., 1915, vol. ix, p. 5.

<sup>4</sup> Elliott and Kaye. *Quart. Journ. Med.*, Oxford, 1916-17, vol. x, p. 363.



noted in 239, or 58·2 per cent., with a mortality of 105, or 43·9 per cent., practically the same as that (43·4) of the total 410 cases.

Other hæmorrhages: In two cases sub-conjunctival hæmorrhages were associated with purpura. In one (fatal) case hæmaturia coincided with a purpuric eruption. Epistaxis was noted in 3 cases (1 fatal); in 2 it occurred while a purpuric eruption was out (1 fatal): in the other twelve days after the rash.

In fatal cases with a recent purpuric rash necropsy commonly showed sub-pericardial, subpleural, and subperitoneal hæmorrhages. In a case fatal on the third day the adrenals were intensely hæmorrhagic, and there were extravasations in the substance of the spleen, but no cutaneous hæmorrhages.

*Herpes labialis* was noted in 35, or 24·4 per cent., of the 143 cases. In one instance the eruption involved the external ear. Herpes generally appeared on the fourth (12 cases) or fifth day (10 cases) of the disease; in two instances herpes and a serum rash occurred together on the eighth and tenth days of the disease. Among the 35 cases 23, or 65·4 per cent., showed also an initial rash, and in one case they appeared on the same day; but usually the herpes came out three or four days after the rash. Eight cases showed an initial rash, herpes and a serum rash; and 10 cases had herpes and a serum rash. In one case labial herpes on the sixth day of the disease occurred two days after an intramuscular injection of soamin 3 gr. Of the 35 cases 5, or 14·3 per cent., proved fatal; this mortality is very much lower than that (36·2 per cent.) of the total 143 cases, thus agreeing with the belief that herpes in cerebrospinal fever is a good prognostic. No fulminating case had herpes, thus contrasting with the hæmorrhagic rash; the 5 cases proved fatal on the eighth, twelfth, fifteenth, fifty-seventh, and sixty-seventh days of the disease. Out of the 410 cases of cerebrospinal fever during the first three years of the war herpes was noted in 91, or 22·2 per cent. Netter<sup>1</sup> finds that among cases in France labial herpes occurs in a third of the cases, and is commoner than purpura. As has been shown above, purpura has been more than twice as frequent as herpes in the Navy during the war.

*Rarer Manifestations and Complications.*—Ocular symptoms. Photophobia, a very early event, was noted in 11 cases; out of 410 cases of cerebrospinal fever during the first three years of the war 42, or 10·2 per cent., had photophobia. Conjunctivitis was reported in 10 instances; usually it occurred at or shortly after the onset, but in one case it was observed on the twelfth day (after the intramuscular injections of 6 gr. of soamin), and in another on the thirtieth day of the disease. Out of the 410 cases it was noted in 24 or 5·8 per cent. Unilateral panophthalmitis in 2 cases necessitated excision of the globe, and in another case, fatal on the fourth day, there was iritis. During the three years of the war destruction of the eye occurred in 5 cases (in one bilateral). Strabismus

<sup>1</sup> Netter. *Rev. de méd.*, Paris, 1917, tome xxxv, p. 133.



occurred in 13 (6 deaths). Out of the 410 cases 42, or 10·2 per cent., had strabismus, and of these, 23, or 54·7 per cent., proved fatal. Ptosis was observed in 5 cases (3 deaths). Out of the 410 cases 15, or 3·6 per cent., had ptosis, and of these 11, or 73·3 per cent., proved fatal. The prognosis, therefore, appears to be worse in cases with ptosis than in those with strabismus. Nystagmus was reported in 5 cases (2 deaths); of the three that recovered one had nerve deafness. Out of the 410 cases, nystagmus was mentioned in 11, or 2·6 per cent. Optic neuritis was detected in 4 (1 death), being early in 2; but few cases were examined.

*Nervous Symptoms.*—Hemiplegia occurred in one case, and after death softening of the internal capsule was found. Out of 410 cases during the three years of the war hemiplegia was noted in 11, or 2·6 per cent. Aphasia and dysarthria each occurred in one case (both recoveries). Dysphagia was noted in 4 cases (2 deaths). Bulbar paralysis was recorded in one instance the day before death. Deafness was recorded in 9 cases, usually nerve deafness; otorrhœa was observed in 1 case. General hyperæsthesia was recorded in 8 cases, and delirium tremens in 2 cases (both recoveries); in the second year of the war delirium occurred in 2 cases (1 fatal). The knee-jerks were absent in 12 cases (3 deaths), and the plantar response was extensor in 14 cases (6 deaths). In the first year of the war the extensor response was recorded in 11 cases; so out of 313 cases it was found in 25, or 8 per cent. No special significance could be attached to these alterations of the knee-jerk and plantar response.

*Other Clinical Features.*—Bronchitis was well marked in 8 cases (5 deaths), and was a grave complication. Pleurisy was noted in one case only (recovery). Mitral incompetence was diagnosed in 5 cases (all recovered), as compared with 5 cases (1 death), in the second year of the war. Pericarditis appeared in one case; out of the 410 cases during the three years of the war it was noted in 7 (3 deaths). Albuminuria was noted in 5 cases (1 death), in one instance coinciding with a serum rash and œdema of the genitals. Polyuria was observed in 1 case, and pyuria in 2 cases. One case (recovery) had temporary glycosuria and albuminuria on the second day of the disease. In 3 cases furunculosis was troublesome during convalescence. Inflammation of the right parotid (non-suppurative) on the sixth day of the disease was noted in 1 case (recovery).

Arthritis was noted in 8 cases (1 fatal) on the third, fourth, fifth, fifth, seventh, eighth, ninth, and thirteenth days, affecting the knee (3), knees, ankles and wrists, wrists and ankles, elbow, ankle and finger, and several joints. In 2 of the cases there was iridocyclitis. Seven of the 8 cases had purpura; and in connection with the view that arthritis when associated with purpura is due to hæmorrhage into the synovial membrane it may be mentioned that in another case the onset of purpura was accompanied by joint pains. According to Netter<sup>1</sup> meningococcic purpura

<sup>1</sup> Netter. *Rev. de méd.*, Paris, 1917, tome xxxv, p. 133.



is prone to be associated with arthritis, iridocyclitis, and malignant endocarditis; among 410 cases of cerebrospinal fever in the Navy during the first three years of the war there was one case in which recent endocarditis was found at the necropsy. In one case only was aspiration necessary, the pus being sterile. In one case effusion into the knees, ankles, and wrists occurred on the fifth day of the disease, and on the eleventh and twenty-second days there were serum rashes, the second of which was accompanied by arthralgia. In this case and in the case with arthritis of the wrists and ankles there was panophthalmitis subsequently requiring excision. The case with arthritis of the elbow was left with weakness of the extensor muscles of the wrist. Usually the effusion was transient, but in one instance the knee-joint contained fluid for six weeks. Among 410 cases of cerebrospinal fever in the Navy during the first three years of the war there were 20 cases of arthritis, or 4·8 per cent. Five, or 25 per cent., of these were in fatal cases.

Orchitis or epididymitis without gonorrhœa occurred in 5 cases, on the sixth, eighth, ninth, eleventh, and twelfth days of the disease. In 3 cases it occurred at the same time as a serum rash and in one of these there was concomitant œdema of the genitals, an association mentioned by Goodall;<sup>1</sup> the other 2 cases did not show a serum rash. In 2 cases the orchitis or epididymitis was bilateral, in the other 3 it was unilateral. Two of the 5 cases had previously had herpes. None of the cases proved fatal. Among the 410 cases of cerebrospinal fever in the Navy during the first three years of the war, orchitis or epididymitis without evidence of gonorrhœa was noted in 8 cases or 1·95 per cent. This is a recognized complication of cerebrospinal fever, and 2 cases showing synovitis and epididymitis, and thus recalling the morphological resemblance of the meningococcus and gonococcus, have been recorded (Eschbach and Lacaze<sup>2</sup>).

In 3 cases, all fatal, secondary or double infection of the meninges occurred; in one instance the second lumbar puncture showed streptococci as well as meningococci which were in pure culture in the first lumbar puncture fluid; in the 2 other cases the additional infection was found at the necropsy; in one tuberculous meningitis (fatal on the eighteenth day) and in the other, fatal on December 14, 1916 (eleventh day), pneumococcic. In the second year of the war there was 1 case of mixed meningococcic and pneumococcic infection without any obvious focus (detected at the first puncture, recovery), and 2 of streptococcic invasion (otitic, and infection from lumbar puncture wound, both fatal). So out of 247 cases secondary or double infections occurred in 5, or 2 per cent.; the case of combined tuberculous and meningococcic meningitis

<sup>1</sup> Goodall, E. W. "System of Medicine" (Allbutt and Rolleston), 1911, vol. ix, p. 114.

<sup>2</sup> Eschbach et Lacaze. *Bull. et mém. Soc. méd. des hôp. de Paris*, 1915, 3e sér., tome xxxix, p. 1024.



raises the question which was primary, for although the onset with a rash becoming hæmorrhagic was that of meningococcic infection, this may have been favoured by the presence of latent tuberculous meningitis; of this rare combination Bériel and Durand<sup>1</sup> accepted 8 cases only. The date of the pneumococcic case is of interest in connexion with Netter and Salanier's<sup>2</sup> 22 cases of secondary pneumococcic infection of meningococcic meningitis treated by serum during the first four months of 1917 when, from the increase of primary pneumococcic meningitis since December, 1916, the virulence of the pneumococcus was presumably intensified.

*Diagnosis.*—Only cases proved to be meningococcic by bacteriological examination of the cerebrospinal fluid have been included in these 143 cases. Some criterion must be employed so as to exclude cases of meningitis due to undetermined factors and cases of meningism, and this bacteriological test is obviously the most satisfactory. That cases of meningococcic meningitis may thus be ruled out is shown by the occasional failure to find meningococci in the cerebrospinal fluid during life and its subsequent discovery at the necropsy. But the statistical error thus introduced is probably much less than that which would result from the inclusion of cases diagnosed from the clinical manifestations, and in the latter event it would be difficult to know where to draw the line, as no one sign or symptom is pathognomonic of meningococcic as opposed to other forms of meningitis. Cases with meningeal symptoms and meningococci in the nasopharynx but not in the cerebrospinal fluid, though possibly genuine cases and therefore demanding prompt serum treatment, have not been included in the 143 cases, as they may have been examples of carriers with meningism due to other causes.

The diagnosis in the possibly abortive cases arising in association with cases of proved meningococcic meningitis is difficult. Groups of such cases occurred in the boy-training establishments at Shotley (July-August, 1916) and in the "Powerful" (December, 1916); the Shotley cases presented meningitic symptoms, but among the "Powerful" cases febrile purpura without meningeal manifestations was prominent, thus suggesting transient meningococcæmia. Netter, in his account of meningococcic purpura without meningococci in the cerebrospinal fluid, states that the diagnosis can be made by a blood culture and by the discovery of meningococci in the contents of bullæ produced by friction of the purpuric spots. But in the "Powerful" cases these tests were negative. Such cases recover. For the purposes of this analysis bacteriological proof of meningococcic infection has been demanded, but in practice antimeningococcic serum should be given to probable cases pending the results of laboratory examination. A clear cerebrospinal fluid at the first puncture does not

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<sup>1</sup> Bériel et Durand. *Lyon méd.*, 1913, tome cxxi, p. 913.

<sup>2</sup> Netter et Salanier. *Bull. et mém. Soc. méd. des hôp. de Paris*, 1917, 3e sér., tome xli, pp. 789-794.



exclude cerebrospinal fever, and on the other hand a turbid fluid at the second puncture—serum having been given on the first occasion—is not evidence of infective meningitis, as the serum may cause a polymorphonuclear exudation. Cases with cerebrospinal fluid turbid from predominance of polymorphonuclear leucocytes on the first tapping but without demonstrable meningococci present great difficulty; they should of course be treated by anti-meningococcic serum, and their recovery is evidence in favour of a meningococcic origin, not only from the point of view of this therapeutic test but also because other forms of polymorphonuclear meningitis usually prove fatal. The bacteriological criterion obviously enables a more accurate view to be taken of the effects of serum treatment; and having adopted this standard it is unnecessary to discuss the differential diagnosis from other forms of meningitis and from the meningism so comparatively common in association with acute infections.

### (3) SUMMARY OF THE RESULTS OF TREATMENT.

Six out of the 143 cases were recognized after death only and were not treated for the disease; 9 cases (4 fatal) had lumbar puncture only; and 11 cases in addition to lumbar puncture had intramuscular injections of soamin (2 cases, both fatal), quinine 20 gr. (1 case, recovery), or both (8 cases, 2 deaths). So that out of 26 cases which did not have serum treatment 14 or 53·8 per cent. proved fatal. In the first year of the war, when the serum available appeared to be inert, the mortality of the 170 cases was 90, or 52·6 per cent., or much the same. Among the 117 cases treated by some form of serum the mortality was 38 or 32·4 per cent., or almost the same as in the second year of the war, namely, 30 deaths, or 31·6 per cent., out of 95 cases treated by serum. During these two years, therefore, 212 cases were treated by serum with a mortality of 68 or 32 per cent. This forms a striking contrast to the mortality of 64 or 61 per cent., among 105 cases treated by serum during the first year of the war when Flexner's serum was not available. During the second and third years of the war 143 cases received Flexner's serum alone or in combination with other serums, and 41 of these, or 28·6 per cent., proved fatal, the mortality of the 109 cases treated by Flexner's serum alone being 30 or 27·5 per cent., and of the 34 cases treated by Flexner's serum in combination with other serums 11, or 32·3 per cent. During the third year of the war Flexner's serum was used in 104 out of the 117 cases treated by serum. In 82 cases it was the only serum employed with a mortality of 24 or 29·2 per cent.; among 22 cases in which it was employed in combination with other serums (Gordon's, Lister Institute, Mulford, and Burroughs, Wellcome and Co.'s), the mortality was 8, or 36·4 per cent.; and among the 13 cases treated by serums other than Flexner's there were 6, or 46·3 per cent., deaths. These cases were given Gordon's serum (7 cases, 3 deaths), Toronto Laboratory's (2 cases, recoveries), Mulford's



(1 case, fatal), the Lister Institute's multivalent (1 case, recovery), Lister Institute's multivalent and Pasteur Institute's multivalent (1 case, fatal), and in one case (fatal) the brand of serum could not be elicited. Flexner's serum therefore appeared to give the best results.

Out of the 117 cases 96, or 82 per cent., received the serum intrathecally within the first three days of the disease with a mortality of 31 cases, or 32 per cent., which is lower than that of the 17 cases commencing serum treatment between the fourth and seventh days of the disease, namely 7, or 41 per cent. But among the 4 cases in which serum treatment was begun after the seventh day there were no deaths. During the second and third years of the war 212 cases were treated by serum, and the combined figures give much the same result as in the third year of the war. The statistics of the first year of the war have not been utilized as the serums then in use appeared to be inert.

Day on which serum treatment was begun	Cases	Deaths	Recoveries
1st to 3rd day ...	170	53 or 31.2 per cent.	117 or 68.8 per cent.
4th to 7th day ...	32	12 „ 37.5 „	20 „ 62.5 „
Later than 7th day...	10	3 „ 30 „	7 „ 70 „
	212	68 or 32 per cent.	144 or 68 per cent.

The number of cases treated late by serum is too small to throw doubt on Flexner's statistical evidence, based on analysis of 1,211 cases, that the mortality rises progressively with delay in beginning the serum treatment; but it is obvious that cases which survive without serum treatment until after the seventh day are not fulminating, and probably some are so mild as to recover spontaneously.

The number of occasions on which serum was given intrathecally varied from one to fourteen. The best results were obtained in 88 cases receiving from two to six injections, namely, a mortality of 23, or 26 per cent.; out of the 15 cases that had seven or more injections 8, or 53 per cent., proved fatal.

Fourteen cases received one injection only of serum, and 7 proved fatal, 5 being fulminating cases; 27 received two doses (6 deaths); 20 three doses (4 deaths); 16 four doses (6 deaths); 16 five doses (5 deaths); 9 six doses (2 deaths); 7 seven doses (4 deaths); 1 eight doses (recovery); 1 nine doses (fatal); 2 ten doses (1 death); 2 eleven doses (1 death); 1 twelve doses (fatal); and 1 case fourteen doses (recovery). Lumbar puncture was performed twenty-seven times in a fatal case which received ten intrathecal injections, and twenty-six times in a case that recovered and also had ten injections. The case tapped on twenty-seven occasions had a hernia cerebri from an old injury which swelled up when the intracranial pressure rose.

The following figures bear on the question of the effect exerted by hypodermic or intramuscular injection of the serum: 36 cases received serum hypodermically or intramuscularly, but as they all had serum intrathecally as well there are no data bearing on the effect of the hypodermic



or intramuscular method alone.<sup>1</sup> Out of these 36 cases 14, or 39 per cent., proved fatal, whereas of the 81 cases treated solely by intrathecal injection of serum 24, or 29·6 per cent., proved fatal. If the corresponding figures for the second year of the war are added it is seen that out of 59 cases receiving hypodermic or intramuscular in addition to intrathecal injections of serum 21, or 35·6 per cent., proved fatal, whereas out of 141 cases treated by intrathecal injections alone 42, or 29·8 per cent., were fatal. (The figures for the first year of the war are not utilized as the serum then employed appeared to be inert.) There is therefore no evidence that hypodermic or intramuscular injection enhances the effect of the intrathecal injection of serum; it would not be fair to draw any further conclusions, as in some cases the hypodermic or intramuscular method was probably employed because of the severity of the patient's condition.

Intravenous, in addition to intrathecal and hypodermic injection of serum, was tried in 2 cases (1 fatal).

The quantity of serum given varied very much; the largest amount given intrathecally was 240 c.c. in a fatal case, but a case that recovered received 210 c.c. intrathecally. In 77 cases that recovered the amounts given, which in some cases include hypodermic or intramuscular injections of serum, may be arranged as follows:—

Received 30 c.c. or less	...	...	...	11 cases
„ between 30 and 60 c.c.	...	...	...	30 „
„ „ 60 „ 100	„	...	...	17 „
„ „ 100 „ 200	„	...	...	16 „
„ over 200 c.c.	...	...	...	3 „
The extremes were 15 and 250 c.c.				

In addition to Gordon's serum intrathecally two cases were given intravenous injections of tartrate of antimony; one case had three such injections and proved fatal, the other had one such injection and recovered. A stock vaccine was given to one case only (fatal).

*Serum rashes*, urticarial, erythematous, morbilliform, or in a very few instances scarlatiniform, occurred in 58, or 60 per cent., out of the 96 cases treated by serum and surviving for more than ten days, and on an average appeared ten days after the first injection of serum. Out of the 241 cases given serum and surviving for ten days or more during the first three years of the war 99, or 41 per cent., had a serum rash. During the second year of the war serum rashes, which were noted in 30 per cent. of the 74 cases given serum and surviving for more than ten days, were found to be specially connected with the use of Flexner's and of Burroughs, Wellcome and Co.'s serums. During the past year this was even more

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<sup>1</sup> Flexner insists that, as very little serum from the blood reaches the inflamed meninges, it is useless to inject it subcutaneously or intravenously in the expectation that it will exert any influence on the meningococci in the subarachnoid space. ("Mode of Infection, Means of Prevention, and Specific Treatment of Epidemic Meningitis," p. 35, 1917, Rockefeller Institute for Medical Research.)



obvious as regards Flexner's serum, for out of the 58 cases of serum rash 56 received this brand of serum, and the rise in the incidence of serum rashes from 30 to 60 per cent. is coincident with the increased use of Flexner's serum, namely, from 39, or 41 per cent., of the 95 cases treated by serum during the second year of the war to 104, or 89 per cent., of the 117 treated by serum during the third year of the war. The serum rash is a non-specific protein reaction due to a foreign protein, and it might be suggested that the reason why Flexner's serum is, as shown below, so remarkably prone to produce this reaction in British subjects is that it is obtained from horses in America.

Out of the 82 cases receiving Flexner's serum only there were 51, or 62 per cent., with rashes; but out of the 82 cases 11 died before the occurrence of a serum rash could be excluded, so that out of the 71 cases which recovered (58) or (if fatal) survived for more than ten days (13 cases) 51, or 71 per cent., had a serum rash. Out of the 58 cases that recovered there was a serum rash in 45, or 77·6 per cent., and out of the 13 fatal cases surviving more than ten days in six, or 46 per cent. These figures, though small, point to the lower incidence of a serum rash in the graver cases. Out of 22 cases given Flexner's and other brands of serum 17 recovered or survived more than ten days, and 5, or 30 per cent., of these had a rash; thus the percentage incidence of serum disease was less than in cases treated solely by Flexner's serum. Out of 13 cases treated by serums other than Flexner's 8 recovered or lived more than ten days, and of these 2, or 25 per cent., had a serum rash.

Flexner's serum was given hypodermically as well as intrathecally in a number of cases; and out of 26 of these cases that recovered or (if fatal) survived for more than ten days a serum rash was noted in 11, or 42 per cent.; whereas out of 61 cases which received Flexner's serum by the intrathecal route only and recovered, or (if fatal) survived for more than ten days 43, or 70 per cent. manifested a serum rash. As far as these figures go, the serum rash appears to be commoner after intrathecal injection alone than after the combined intrathecal and hypodermic injection. Out of Currie's<sup>1</sup> 50 cases of cerebrospinal fever treated mainly by subcutaneous injection of serum (36 cases subcutaneous injection only, 13 cases with one intrathecal and the remaining injections subcutaneously, and one case with one intrathecal and one intravenous and the remaining injections subcutaneously) 29, or 58 per cent., had rashes. Comparison of Currie's and the 61 Naval cases (with 70 per cent. of rashes) confirms Flexner's<sup>2</sup> remark, that possibly the manifestations of serum disease are more frequent after this intrathecal than after the subcutaneous method of injection employed in serum therapy generally. These, however, are small and selected groups of figures and do not justify a final conclusion. Goodall<sup>3</sup> says that analysis of a large number of cases shows that about a third of the patients

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<sup>1</sup> Currie, J. R., *Journ. Hyg.*, Cambridge, 1908, vol. viii, p. 457.

<sup>2</sup> Flexner, S., *loc. cit.*, p. 42, 1917.

<sup>3</sup> Goodall, E. W., "System of Medicine" (Allbutt and Rolleston), 1911, vol. ix., p. 113.



receiving ordinary hypodermic injections of serum have a rash; but some statistics show a higher percentage,<sup>1</sup> and among 37,277 cases of diphtheria injected with serum at the Metropolitan Asylums Board Hospital (1898-1903), the incidence of rashes was 44 per cent., or rather more than that (41 per cent.) among the 241 cases of cerebrospinal fever given serum during the first three years of the war. It cannot, therefore, be said that the incidence of serum rashes is proved to be higher after the intrathecal than after the ordinary method of injecting serum.

In cases treated by subcutaneous as well as intrathecal injection of serum the serum rash may begin around the site of the subcutaneous puncture and subsequently become general.

Quite commonly a serum rash appears, fades, and about two days later again becomes prominent; the first may be erythematous and the second urticarial and extremely irritating. These may be regarded as phases of the same reaction. In rare instances two serum rashes appear at such an interval as to justify the term *double serum rash* and to suggest two separate reactions, which might be supposed to be the result of injections on different days; a number of Currie's cases also bear this interpretation; this, however, as shown by the second of the following cases, is not universally true; and the occurrence of two or three distinct rashes after a single injection of serum is now thought to be due to the successive appearance, at different time intervals, of sensitiveness to the different proteins—euglobulin, pseudo-globulin, and albumen—present in horse serum (Dale and Hartley).<sup>2</sup>

After intrathecal injections on the third, fourth, and sixth days of the disease, there was an erythema on the eighth day which faded on the ninth and reappeared on the eleventh day. On the eighteenth day there was a recurrence of the rash. In another case a double serum rash followed the administration of serum on one day only, the second day of the disease, when intrathecal, intravenous, and hypodermic injections were given; serum rashes appeared on the tenth and on the twenty-fifth days.

There is another category of double serum rashes: when in a chronic case an ordinary serum rash occurs and subsequently after a period during which no serum has been given and anaphylaxis has developed, a further injection is given with the rapid appearance of a rash.

A man had a serum rash seven days after he first had serum; thirty-six days later, no serum having been injected for twenty days, a further injection was given, followed next day by an immediate serum rash without constitutional symptoms of anaphylaxis. In a somewhat similar case there were serious constitutional symptoms and a hæmorrhagic rash (*vide* p. 33).

The quantity of serum administered had very little influence in inducing a serum rash; this appears to be contrary to the general experience. Among 58 cases that had Flexner's serum only and recovered:—

<sup>1</sup> Notably those of J. D. Rolleston (*Practitioner*, 1905, vol. lxxiv, p. 660), from 67 to 81 per cent.

<sup>2</sup> H. H. Dale and P. Hartley. *Biochem. Journ.*, Cambridge, 1916, vol. x, p. 408.



23	received less than 50 c.c. of serum, and 18, or 78 per cent., had a rash.
24	„ more than 50 c.c. and less than 100 c.c., and 19, or 79 per cent., had a rash.
8	„ more than 100 c.c. and less than 150 c.c., and 7, or 87 per cent., had a rash.
3	„ more than 150 c.c., and 2, or 67 per cent., had a rash.

It was pointed out by Currie<sup>1</sup> that an injection of anti-diphtheritic serum just before a serum rash due to a previous injection might be expected may determine the appearance of a rash which otherwise would not have developed. Examination of the notes does not show that this sequence is established in cerebrospinal fever. It is true that in a few cases lumbar puncture and the injection of serum have been performed the day before the rash appeared, there having been a previous interval of some days without the administration of serum. But such cases are perhaps more satisfactorily explained by the view that the symptoms of cerebral pressure which led to the lumbar puncture and the injection of serum were premonitory of the serum rash (*vide infra*).

In 3 cases œdema of the scrotum accompanied the serum rash and in one of these there was transient albuminuria. In a fourth case the eyelids were œdematous. In 5 cases pains in the joints accompanied or followed the serum rash, and in one of these there was a double serum rash (on the eleventh and twenty-second days after the first injection) and each eruption was associated with arthralgia. In 6 cases the serum rash was followed, usually after an interval of four days, by synovial effusion, commonly of the knees or wrists, sometimes but not always painful. This well known association of erythematous eruptions and joint symptoms suggests a similar change in both situations. In one case a painless effusion into the left knee-joint occurred seven days after the first injection of serum, although there was no rash. The rash may be accompanied by fever and enlargement of the lymphatic glands.

In 9, or 15·5 per cent., out of the 58 cases the serum rash was preceded or accompanied by a recrudescence of meningeal symptoms which were relieved by lumbar puncture. This manifestation of serum disease, well described by Netter and Debré,<sup>2</sup> appears to be peculiar to the intrathecal injection, and its mechanism may perhaps be elucidated by analogy. The liability of the mucous membranes originally attacked by diphtheria to swell at the time of the subsequent serum reaction may be shared by the meninges in cerebrospinal fever; and it may be suggested that the meninges show a change corresponding to the rash and œdema which sometimes begin around the site of a hypodermic injection of serum. This form of meningeal irritation or meningism can be distinguished from a true relapse of meningococcic infection by examination of the cerebro-

<sup>1</sup> Currie, J. R. *Journ. Hyg.*, Cambridge, 1907, vol. vii, p. 35.

<sup>2</sup> Netter et Debré. "La méningite cérébrospinale," p. 264, Paris, 1911.



spinal fluid for the presence of meningococci, and also for the normal reducing agent (glucose) which is absent in a genuine relapse but present in the meningism of serum disease (Reveillelet, Nové-Josserand and Langeron).<sup>1</sup> This latter test, which can be done in a few minutes, and so is useful in deciding whether at once to give serum intrathecally (relapse) or to withhold it (meningism) has been used by Staff Surgeon L. Warren in the "Agadir," and by Dr. C. Ker<sup>2</sup> at the City Hospital, Edinburgh, where some Naval ratings have been treated.

Out of the 58 cases showing serum rashes, 7, or 12 per cent., proved fatal. The average duration of these fatal cases was twenty-six days, the extremes being fifteen days (in 2 cases) and fifty-six days (the next longest case lasting thirty-one days). Nineteen cases had both an initial rash and a serum rash (double in three instances), 10 cases both herpes labialis and a serum rash, and 8 cases an initial rash, herpes, and a serum rash (double in two instances); in those cases the skin was presumably prone to react in a special degree.

*Grave accidents* due to lumbar puncture and the intrathecal injection of serum were rare, and should not occur if the obvious causes be avoided. The cases may be divided into those (1) due to increased intracranial pressure:

A man on the third day of the disease had lumbar puncture for the third time, 5 c.c. of fluid not under pressure being removed; 40 c.c. of serum was given and respiration stopped; artificial respiration was followed by improvement, but he died five hours later. At the necropsy the lateral ventricles were distended with purulent fluid. A man on the second day of the disease was lumbar punctured for the first time and 30 c.c. of turbid fluid removed; 20 c.c. of serum was given intrathecally and he collapsed with respirations of 10 and a pulse of 120 per minute. Artificial respiration was followed by recovery. During the second year of the war there were three cases of this nature.

(2) due to anaphylaxis:

On the forty-eighth day of the disease, not having had any serum for twenty-seven days, a man had an intrathecal injection of 20 c.c.; seven hours later he vomited, had a purpuric rash and was gravely ill. Next day the rash had faded but the right knee was full of fluid. He died seven days after the injection.

(3) due to infection through the lumbar punctures:

After thirteen lumbar punctures and the intrathecal injection of 240 c.c. of serum, a man was on the twenty-ninth day of the disease found to have a swelling resembling a hæmatoma over the lumbar spine; incision next day gave exit to blood-stained fluid and some débris. Death occurred suddenly next day. As there was no necropsy the nature of the infection was not determined.

In one case lumbar puncture without injection of serum was followed by pain and tenderness in the course of the left sciatic nerve and some wasting of the limb.

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<sup>1</sup> Reveillet, Nové-Josserand, et Langeron. *Journ. de physiol. et path. gén.*, Paris 1914-15, tome xvi, p. 1080.

<sup>2</sup> *Vide also Lancet*, 1917, vol. ii, p. 822.



## (4) HISTORY OF THE OUTBREAKS OF CEREBROSPINAL FEVER AT VARIOUS CENTRES.

*The Portsmouth District.*

Forty-six cases with 15 deaths, or 32·6 per cent., were reported from this area, as compared with 28 (8 deaths, or 28·5 per cent.) in the second, and 36 (19 deaths, or 52·7 per cent.) in the first year of the war. In the first three years of the war there were therefore in this district 110 cases of cerebrospinal fever, or 26 per cent., out of the total 417 cases in the Navy, as compared with 94 (22·5 per cent.) in the Plymouth District, 49 (11·7 per cent.) in the Chatham District, 59 (14 per cent.) at the Crystal Palace Depot, 26 (6 per cent.) at Shotley, and 42 (10 per cent.) in sea-going ships. Out of the 110 cases there were 42 deaths (38 per cent.) out of the 179 deaths (42·9 per cent.) among the 417 cases in the Navy. The 46 cases were drawn from the Royal Naval Barracks (36), from the Royal Marine Artillery Barracks, Eastney (4), Haslar Isolation Camp (3), Royal Marine Light Infantry Barracks, Forton (1), H.M.S. Vernon (1), and Calshot Air Station (1).

The monthly incidence of cases in the Royal Navy in this district was: October 1, November 3 (1 death), December 5 (2 deaths), January 8 (4 deaths), February 12 (3 deaths), March 10 (5 deaths), April 4 (0 death), May 1 (recovery), and June 2 (0 death). Dr. Mearns Fraser, M.O.H. for Portsmouth, has kindly given me the incidence of cerebrospinal fever in the civil population: From August to December, 1916, there were 5 cases, in January 11, February 13, March 17, April 8, May 5, June 1, July 1. In all 61 cases as compared with 45 in the Navy; in both series almost exactly 67 per cent. of the cases occurred during the first three months of 1917. In the two previous years of the war the highest incidence of Naval cases in the Portsmouth district was in March. During the three years of the war, January (21), February (21), and March (30 cases) provided three-quarters of the cases, the month with the next highest incidence being April (9 cases). The 46 cases were treated at the Royal Naval Hospital, Haslar, by Staff Surgeon G. P. Adshead; they all received Flexner's serum, and 3 (2 deaths) received Mulford's serum in addition. Five cases (3 deaths) had subcutaneous as well as intrathecal injections of serum.

The following information was kindly provided by Hon. Staff Surgeon P. Fildes, M.B., R.N.V.R.: Among 10,899 new entries swabbed there were 366, or 3·3 per cent., carriers; the months of December (3·6 per cent.), January (5·4), February (4·6), and March (3·8) showed a percentage above the average. Among 1,350 contacts there were 112, or 8·3 per cent., carriers, 101 of which were detected in the months December to April, and 81 in January, February and March. In the second year of the war there were no carriers among 2,022 new entries swabbed, and among 603 contacts 25, or 4·1 per cent., carriers. No case of a carrier going sick with the disease<sup>1</sup>, or of a contact developing the disease within ten days, or of a case due to contact with a carrier, has been detected. With regard to the occurrence of Gordon's four types of meningococci: there was an epidemic of types I and III until late in February, after which there were occasional cases only. Types II and IV maintained a high level until the end of March, when there was a fall followed by a steep rise in May and June, after which there were sporadic cases only. There was no outstanding predominance of any type among the cases of cerebrospinal fever, but it is noteworthy that type I persisted among the cases after it had ceased to appear among the carriers. The results of a comparison between the clinical manifestations and the presence of the various types will be published by Staff Surgeon G. P. Adshead. The carriers were segregated and experiments with various antiseptics were tried: chloramine-T (steam spray in inhalatorium, and also nasopharyngeal spray), flavine 1 in 500 (nasopharyngeal spray), carbolic acid 1 in 200, and permanganate

<sup>1</sup> *Vide* also Fildes and Baker, *Lancet*, 1917, vol. ii, p. 602.



of potassium (nasal spray). Roughly 50 per cent. of the carriers were rendered sterile by all the forms of treatment, so no one is of conspicuous merit, especially as probably 50 per cent. recover spontaneously.<sup>1</sup>

*Royal Naval Barracks, Portsmouth.*—During the third year of the war 36 cases occurred in the Royal Naval Barracks or its overflow establishments (not including the isolation camp at Haslar) as compared with 14 in the second and 16 in the first year of the war. Out of 417 cases in the Navy during the three years of the war 66 cases (15·8 per cent.) arose in these barracks as compared with 43 (10 per cent.) in the barracks at Devonport, 42 (10 per cent.) at Chatham, and 59 (14 per cent.) at the Crystal Palace Depot.

The first case arose in an overflow establishment at Pitt Street, Portsmouth, on October 27, 1916; the next case on November 12 was in an assistant steward who had been ten days in the Service; sixteen days later there was a third case, and on November 30 a case in an overflow ship. During January there were 8 cases, all in new entries, of which two came from the same room but not from the same mess. In February there were 9 cases, 7 having been in the Service less than four weeks; there were two instances of 2 cases arising in the same room and in adjacent messes. During March there were 10 cases; on March 3 and 4 cases arose in the same mess in a room where a case occurred on February 6, and on March 12 and 31 cases occurred in another room in a mess which also had cases on February 19 and April 17. The only other case in April arose in an overflow ship on April 9. Isolated cases occurred on May 28 and June 23.

*The Royal Marine Artillery Barracks, Eastney.*—Four isolated cases occurred on February 22, March 3, April 2 and June 7. The first was in a man, aged 46, who had been under treatment for two weeks for a cold. The second case was rapidly fatal in a man who joined on February 26 and whose throat was negative four days before he went sick with the disease. Out of the 417 cases during the first three years of the war 20, or 4·8 per cent., occurred in these barracks.

*The Royal Marine Light Infantry Barracks, Forton.*—One case only arose in these barracks on February 18. During the first three years of the war 8 cases borne on the books occurred, but only 2 of these were in the barracks.

*Haslar Camp for quarantine of drafts.*—Cases occurred on December 12, 27, and 31. On January 30 a man who had left Haslar Camp two days before went sick with the disease on arrival at his depot ship elsewhere, and in addition on January 31 an unproved but clinically characteristic case arose in the camp. After this no further cases arose.

#### *The Plymouth District.*

Thirty-six cases with 13 deaths, or 36 per cent., were reported from this depot, as compared with 28 (9 deaths or 32 per cent.) in the second year, and 30 cases (11 deaths or 36·7 per cent.) in the first year of the war. During the first three years of the war there were therefore 94 cases with 33, or 35 per cent., deaths at this depot out of the total 417 cases (179 deaths or 42·9 per cent.) in the Royal Navy. Out of the 94 cases 41 with 11 deaths, or 27 per cent., occurred among the boys in the "Impregnable" and "Powerful." The 36 cases were drawn from the Royal Naval Barracks (24), the "Impregnable" (5), the "Powerful" (5), and from the sick berth staff of the Royal Naval Hospital (2), neither of whom were on duty in the zymotic block.

The monthly incidence of cerebrospinal fever in the Navy in this depot was as follows: August 0, September 1, October 0, November 0, December 4, January 10, February 4, March 6, April 4, May 5, June 2, July 0. In the two previous years of the war the largest number of cases arose in February. Thirty-four cases were treated in the Royal Naval Hospital, Plymouth, one case was

<sup>1</sup> *Vide* also Fildes, P., and Wallis, P. B., *Lancet*, 1917, vol. ii, p. 527.



found dead in the barracks, and another died on the way to the hospital, so the mortality of the 34 cases that entered the hospital alive was 11, or 32·4 per cent. In the majority of lumbar punctures a general anæsthetic was given. Of the 34 cases treated by serum intrathecally 29 received it hypodermically also; one case (fatal) had serum intrathecally, hypodermically and intravenously. The hypodermic use of serum was very seldom adopted elsewhere—in 7 cases only. Out of the 34 cases 20 (7 deaths) received Flexner's serum only, 12 (3 deaths) Flexner's together with other brands, and 2 (1 death) serum other than Flexner's.

Fleet Surgeon R. S. Bond found that during the year August 1, 1916, to July 31, 1917, out of 8,793 new entries swabbed there were 12 carriers or 0·1 per cent.; and out of 6,107 contacts 51 carriers or 0·8 per cent.; in the previous year the corresponding percentages found by Fleet Surgeon Whiteside were 1·8 and 9·5.

*Royal Naval Barracks, Devonport.*—There were 24 cases as compared with 4 in the second and 15 in the first year of the war. In the first three years of the war there were, therefore, 43 cases, or 10 per cent., out of the 417 in the Navy, as compared with 66 (15·8 per cent.) at the Portsmouth Barracks, 42 (10 per cent.) at Chatham Barracks, and 59 (14 per cent.) at the Crystal Palace Depot.

The first case arose on September 12, 1916, in a man who had had three abdominal attacks, late in July, in August, and on September 6. There was no further case until December 21, when a man already in hospital for a week with rubella developed the disease; four days later a man in the same room, but not in the same mess at the barracks, who had also been in hospital for six days with rubella, developed cerebrospinal fever; on December 24 a man in an overflow ship ("Eclipse") went sick with the disease. After an interval of sixteen days the fifth case occurred on January 10, the source of infection not being traced; on January 11 and 14 there were cases in the same room as the fifth case, and on January 15 two cases in adjacent messes occurred in the same room as the fourth case. On the same day the tenth case appeared in a man who on January 11 had left the Isolation Camp at Haslar, where there had been a case on December 31. After an interval of twelve days, the eleventh case occurred in the "Eclipse," in a new entry four days after joining the Service, whose throat was free from meningococci. On January 27 the twelfth case came from the same room as the fifth, sixth, and seventh cases, and on January 29 a case arose in a room which had previously been free from infection. After an interval of twenty-eight days the fourteenth case appeared on February 26, in a room which had not had any cases. On March 1 and 3 cases occurred in adjacent messes in a room not previously infected. The seventeenth case on March 7 came from the same room as the first case. On March 15 and 24 isolated cases appeared in rooms previously free from the disease. The twentieth case on April 11 was in a man found dead in his hammock, who as far as was known had not been in contact with any carrier or case of the disease. On April 16 and May 6 the twenty-first and twenty-second cases occurred in new entries who had been with the same overflow ship as the preceding case. On May 20 and 23, two Canadians who landed on April 7 with forty-nine other Canadians, two of whom were found to be carriers, went sick with the disease; their throats had been swabbed and found to be negative soon after arrival at the depot. As there were 4 cases of cerebrospinal fever in the town between April 1 and May 19, and these men had had local leave, it is possible that they became infected in this way.

In the "Powerful" establishment there were 5 cases with 2 deaths, or 40 per cent., as compared with 7 (no deaths) in the second, and 2 (no deaths) in the first year of the war. No case occurred until December 4, 1916, the last previous case having appeared on April 29. The case on December 4 which proved fatal was one of a group of 6 cases occurring between December 4 and 7, and equally divided between "Powerful I" and "Powerful II"; of the other 5 which all recovered, 4 had purpura with fever and 2 meningitic symptoms; none of the 5 were



bacteriologically proved to be cases of meningococcic infection, but subsequently (on April 11, 1917), the case with meningitic symptoms and fever, but without purpura, was found to be a carrier. At least 5 more cases strongly suggesting cerebrospinal fever clinically, but not so proved bacteriologically, occurred in the "Powerful" on December 13, January 28, February 9, May 1 and 31. It is interesting to compare these 10 cases resembling, but not proved, to be cerebrospinal fever with a group of 19 cases, observed by Fleet Surgeon T. D. Halahan, between July 14 and August 14, 1916, at Shotley; 6 of the 19 were bacteriologically proved to be meningococcic, but the whole 19 cases were regarded as the same in nature. In the "Impregnable" establishment, however, no cases of this kind were observed. Staff Surgeon D. H. C. Given will publish an account of the cases in the "Powerful."

The second proved case of cerebrospinal fever occurred on January 17, 1917, in "Powerful II," and was fulminating. A boy who joined the "Vanguard" on February 3 from the "Powerful" developed the disease on February 7. The third case arose in "Powerful II" on February 27, in a boy who joined from Shotley on February 16, and may conceivably have brought the infection with him, as there was a case there when he left, though not in the same dormitory. The fourth proved case arose in "Powerful III" on May 4, three days after an unproved case in the same ship. On May 29 a case occurred in "Powerful II" in a boy who joined on March 20, and had just come on duty after a week's bronchitis.

In the "Impregnable" establishment there were 5 cases with 3 deaths, or a mortality of 60 per cent., as compared with 13 (2 fatal) in the second and 9 (4 fatal) in the first year of the war. The first case occurred on February 5, 1917, in "Impregnable I," the second on February 6 in "Impregnable III." These two cases were unconnected. The third case on April 16 was in a boy who joined "Impregnable III" on March 10, and was transferred to "Impregnable I" on March 16. The necropsy showed tuberculous as well as meningococcic meningitis. On April 30 his schoolmaster was found to be a carrier. On June 14 a boy who had been in the Service a month, and had been transferred from the new entries' mess in "Impregnable III" to "Impregnable I," died after twelve hours' illness. On June 26 a boy who had been in the Service seven days, and whose throat swab was negative on entry, went sick with the disease.

#### *Chatham District.*

The 10 cases reported from this depot were drawn from the Royal Naval Barracks (7), the Royal Marine Light Infantry Barracks (1), the Dockyard (1), and the Royal Naval Hospital (1). In addition to these 10 a black fireman from a collier was treated in the Royal Naval Hospital. Of the 10 cases 3, or 30 per cent., proved fatal as compared with 18 (9 fatal) in the second and 21 (16 deaths or 76 per cent.) in the first year of the war. In the first three years of the war there were, therefore, 49 cases with 28 deaths, or 57 per cent., out of the total 417 cases (179 deaths or 42.9 per cent.) in the Royal Navy.

The monthly incidence of the Naval cases in the Chatham district was as follows: September 2, December 1, January 4, February 2, March 1; in April two unproved cases occurred; the blood of one of them agglutinated Gordon's types I and II: the blood of the other did not agglutinate any. In the two previous years of the war the largest number of cases occurred in February and March. Staff Surgeon A. G. L. Reade, R.N.V.R., informs me that there was a rather severe epidemic of cerebrospinal fever among the military and civilian populations in the district during the winter of 1916-17, and that all the military establishments and private houses where soldiers were billeted were put out of bounds. Carriers and contacts were isolated in a camp on St. Mary's Island. The cases were treated in the Royal Naval Hospital, Chatham, and all had



Flexner's serum; in four instances (1 death), it was the only serum given; the remaining 6 cases (2 deaths), received in addition the Lister Institute multivalent serum, Burroughs, Wellcome and Co.'s, or Mulford's serum. In some of the later and prolonged cases the intrathecal canal was washed out with saline solution before the serum was given.

During the third year of the war Staff Surgeon J. H. Burdett from bacteriological examination of 10,839 new entries found 144 carriers, or 1·3 per cent., the highest incidence being in March and April. Out of 1,044 contacts there were 42 carriers, or 4 per cent.

*The Royal Naval Barracks, Chatham.*—There were 7 cases as compared with 14 during the second and 21 during the first year of the war. In the first three years of the war there were, therefore, 42 (or 10 per cent.) cases out of the 417 in the Navy as compared with 66 (15·8 per cent.) at Portsmouth Barracks, 43 (10 per cent.) at Devonport Barracks, and 59 (14 per cent.) at the Crystal Palace.

The first case occurred on September 28, 1916, in a stoker who had had pneumonia two months previously. On December 18 there was a second case in a ship's steward's assistant who had joined the Navy three weeks before, when his throat was negative for meningococci. On January 5 a case occurred in a man who joined the isolation camp on St. Mary's Island on January 1 from the Crystal Palace, where he had been a cerebrospinal fever contact. Five days later a deck hand had the disease, and then on January 15 a case at first regarded as Vincent's angina appeared. On January 31 a man who joined the Service the day before went sick with the disease. The last case on February 17 was in an officer's servant.

*Royal Marine Light Infantry Barracks Headquarters.*—On February 2, the son of a colour-serjeant, aged 14 years, was removed for treatment and bacteriologically proved to be suffering from meningococcic meningitis. On February 8 a lieutenant-colonel, aged 48 years, contracted the disease.

*Chatham Dockyard.*—A Naval apprentice went sick on March 31 with sore throat, at first thought to be diphtheritic, but when admitted to hospital on April 3 he was unconscious and died six days later.

*Royal Naval Hospital, Chatham.*—A stoker, admitted from a northern base on September 7 for hæmoptysis, developed the disease on September 22; this was the first case to be treated in the hospital during the third year of the war.

### *Crystal Palace.*

At this depot there were 18 cases with 8 deaths, or 44·4 per cent., as compared with 8 cases (2 deaths), in the second, and 33 cases (21 deaths, or 63·6 per cent.) in the first year of the war. During the first three years of the war 59 (14 per cent.) out of the 417 cases in the Navy occurred at this depot. The largest number (7) of cases occurred in March; in the second year of the war the highest incidence was in February (11) and March (10).

As in the two previous years of the war, treatment was carried out at the Croydon Borough Fever Hospital, and I am indebted to Drs. R. S. V. Clark and H. Major for the notes of the cases. One of the cases died before admission and another within a few hours. As anti-meningitic serum was not given to any of the cases, a few words may be said as to the treatment adopted. All the cases were treated by lumbar puncture; in addition 8 were given soamin (3 gr.) intramuscularly and large doses of quinine (20 gr.) by the mouth; these were not fulminating or rapidly fatal cases and 6 recovered; one of the fatal cases in addition had a stock vaccine. One case (recovered) had one dose of quinine and one (fatal) soamin only. Of the six cases treated by lumbar puncture alone 3 died within two days of the onset. The administration of the large doses of



quinine when the temperature was rising was employed by Dr. Major. Eight patients were on admission given a mixture containing liquor arsenicalis; of these 2 died, the 6 who recovered all had quinine and soamin as well.

The first case occurred on December 28, 1916, in a man who had been three weeks in the Service. On January 2, 1917, a rating was taken ill and died at home, but as no bacteriological proof was forthcoming the case is not included as one of the disease. The second case arose on January 4 and the third on January 6, then on January 17 the fourth, followed on January 20 by the fifth and on January 22 by a fulminating case. After an interval of twelve days the seventh case occurred on February 6 and the eighth case on March 2. All these cases were in different parts of the building. The ninth case on March 6 arose in the same dormitory as the seventh case. On March 12 and 17 the tenth and eleventh cases occurred in a dormitory previously free from the disease, and on March 19 the twelfth case arose in another previously uninfected dormitory. On March 28 and 31 cases arose in dormitories in which single cases had occurred on January 6 and 22 respectively. On April 23 the fifteenth case came out of the dormitory responsible for the cases of March 28 and January 6. Four days later the sixteenth case occurred in a dormitory from which a case came on January 17, and on the same day a case arose in a previously uninfected dormitory. The eighteenth case occurred on May 16 in the same dormitory as the seventh and ninth cases on February 6 and March 6. There was thus no obvious grouping of the cases or evidence of persistent infection in any one dormitory.

Between December 4, 1916, and the end of July, 1917, Deputy Surgeon-General P. W. Bassett-Smith, C.B., found among 97 contacts 19 carriers, or 19.5 per cent.; among 11,425 new entries 591, or 5 per cent., carriers; and among 4,151 drafts (including 462 officers) 396, or 9.5 per cent., carriers. The percentage of carriers among the drafts varied more than among the new entries; early in March the percentage rose to 18, while that of the new entries was 5; after a fall to 9 it rose in the middle of May to 23, while that of the new entries was 6 and reached its highest point (9) in July.

#### *Shotley Training Establishment.*

There were 8 cases with 6 deaths, or 75 per cent., as compared with 11 (4 deaths) in the second and 7 (5 deaths) cases in the first year of the war. So out of 26 cases (6 per cent. of the 417 cases) during the first three years of the war 15, or 57.7 per cent., were fatal as compared with the general mortality of 42.9 per cent. among the total 417 cases in the Navy. In addition to the 8 cases one from torpedo destroyer "Surprise" (recovery) and a deck hand from mine-sweeper "Mercury" (fatal) were treated here.

The first case on August 9 was one of a group of 19 cases recorded by Fleet Surgeon T. D. Halahan<sup>1</sup> as cerebrospinal fever, although bacteriological proof was forthcoming in 6 only. The second case, on November 18, was rapidly fatal, the diagnosis being established after death by examination of the cerebrospinal fluid. On December 5 another case was reported, and the fourth case occurred on December 29 in a boy who had been on leave for eight days and died in University College Hospital, London. Between the occurrence on February 9 of the fifth case, which was complicated by chorea, and of the sixth case on March 15 there were 30 cases in the neighbourhood. On May 6 there was a fatal case in a boy who joined on March 14 from the "Impregnable," where he had been for the first half of February in the class of a schoolmaster found on April 30 to be a carrier (*vide* also p. 37). On May 19 a case regarded as cerebrospinal fever clinically, but not so proved bacteriologically, occurred; and on July 5 a boy who

<sup>1</sup> Halahan, *Lancet*, 1916, vol. ii, p. 1102.



complained of a sore throat the night before was found dead and bacteriologically shown to be a case of meningococcic meningitis.

Five cases were treated by intrathecal injections of Gordon's serum with previous lavage of the intrathecal space with 0·5 per cent. carbolic acid in saline solution. In addition, 2 cases (1 fatal) received intravenous doses of antimony tartrate  $\frac{1}{2}$  gr.

#### *Sea-going Ships.*

Twenty bacteriologically proved cases were reported from sea-going ships. In three instances more than one case occurred in the same ship; in the "Calgarian," a transport, two cases arose in the same voyage, and in other voyages two unproved cases arose; in the "Comus" two cases occurred within three days of each other, and in the "Courageous" with an interval of twenty-five days.

The cases occurred in the "Calgarian" (August 13, 20), "Temeraire" (September 10), S.S. "Westgarth" (October 13), "Gibraltar" (October 31), "Valiant" (November 18), "Colossus" (November 28), "Mercury" a mine-sweeper (December 19), T.B.D. "Salmon" (January 24), "Sandhurst" (arriving ill from Haslar Camp, January 30), "Vanguard" (February 7), T.B.D. "Surprise" (March 13), "Ajax" (March 17), "Campania" (April 11), "Courageous" (May 6, 31), "Orion" (June 19), "Comus" (July 10, 13), and "Hercules" (July 17). The average age of the twenty cases was 20·5 years, of the recoveries 20·4 years, and of the fatal cases 20·8 years. Out of the twenty cases, 6, or 30 per cent., proved fatal as compared with 5 out of 10 during the second, and 8 out of 12 during the first year of the war. Thus among 417 cases during the first three years of the war, 42, or 10 per cent., occurred in sea-going ships, but in four instances only were there more than one case in the ship. Among these 42 cases there were 19 deaths, or 45·2 per cent., as compared with the 42·9 per cent., mortality for the 417 cases.

#### *Other Places.*

Two cases occurred in different depot ships in Rosyth Dockyard on April 8 and May 3 and were treated in the City Hospital, Edinburgh. Isolated cases also occurred in a depot ship at a Northern base on January 5, at a Royal Naval Air Station in Yorkshire on February 18, and at Folkestone on September 11.

In addition to the medical officers incidentally mentioned, I beg to express my sincere thanks for courteous help and information to Surgeon-General W. W. Pryn; Deputy Surgeons-General R. Hill, C.V.O., P.M.O. of the Grand Fleet; W. Bett, M.V.O.; Fleet Surgeons A. MacLean, D.S.O., W. H. S. Stalkartt, A. R. Bankart, C.V.O., T. T. Jeans, H. S. Burniston, W. MacLeod, J. A. Campbell, R. M. Richards, W. L. Martin; Surgeon J. R. Adam; Temporary Surgeons J. P. Berry, B. A. Playne, D.S.O., E. J. Tongue, and A. Viney.









